**Device for Manipulating an Object, Method for Filling an Object, and Corresponding Use**

The ~~invention~~ disclosure concerns a device for manipulating an object, wherein the object is movable contactlessly on a drive surface by at least one mover which is magnetically coupled to a stator arrangement.

It is usual to carry out special production processes which require a controlled and/or sterile environment in protected interior spaces. Such protected interiors include inter alia clean rooms, such as for example isolators, containments or radioactively charged rooms. Protected interiors are often used inter alia in the production of semiconductors, in the aviation and aerospace industry, and in the aseptic production or packing of foodstuffs and pharmaceutical or cosmetic products. Semi- or fully automated process steps are largely used for optimising the special production processes. However, often widely varying process steps are carried out by human hand, which can lead to contamination of the products to be produced even if the process is carried out inside a protected interior space.

Devices for manipulating objects are known in the industry. Manipulation here may for example be any process which may take place in a device for processing and/or production of a product. For example, in the pharmaceutical industry, injection vials are conducted via a conventional flow conveyor, a transport star or transport rake firstly to a filling device where they are filled, in order then to be transported on to further process stations via the flow conveyor. Such systems may be relatively inflexible, susceptible to fault and maintenance-intensive.

Recently, devices for manipulating objects have been known, in which a transport body known as a mover is movable and/or rotatable in at least two degrees of freedom, preferably contactlessly in an electromagnetic field. The mover is magnetically coupled to a stator arrangement (planar motor system) and levitates contactlessly a few millimetres above the stator

arrangement. The stator arrangement consists of at least one sheet packet and may be positioned in modular fashion and modified to the existing spatial conditions.

The ~~invention~~ disclosure furthermore concerns a method for filling an object which is transported by a mover on a boundary wall of a protected interior to a filling device and filled by the filling device.

The ~~invention~~ disclosure furthermore concerns the use of a boundary wall of a protected interior as a drive surface.

The ~~invention~~ disclosure is based on the object of expanding the use of protected interiors and making this more flexible.

In a first aspect, the present disclosure provides a device for manipulating an object, wherein the object is movable contactlessly on a drive surface by at least one mover which is magnetically coupled to a stator arrangement, characterized in that the drive surface is configured as a sealed border, in particular as a boundary wall, of a protected interior.

To achieve said object, according to the ~~invention~~ disclosure the features of claim 1 are provided. In particular, to achieve said object in a device of the type described initially, it is provided that the drive surface is configured as a sealed border, in particular as a boundary wall, of a protected interior. According to the ~~invention~~disclosure, this may include the entirety of the boundary walls or parts thereof. Thus the drive surface may also extend onto further, possibly non-horizontal, surfaces within the protected interior, whereby an expanded functionality and/or work capacity and/or greater flexibility can be achieved. Thus the stator arrangement may be formed on the boundary wall of the protected interior, whereby at the same time space and materials can be saved.

It is advantageous here that transport in the protected interior is abrasion-free. Thus less cost is required for cleaning. This also achieves that during production, no particles are released which could cause contamination, for example during filling.

In a further advantageous ~~embodiment~~ example of the ~~invention~~disclosure, it may be provided that the stator arrangement is arranged outside a protected interior. Thus the stator arrangement can be isolated from the conditions in the interior. For example, it may be provided that the stator arrangement is attached to a boundary wall. This gives a particularly compact variant. It may be provided here

that the boundary wall is arranged vertically and/or horizontally and/or sloping. Thus boundary walls with different orientation may be used.

In an ~~embodiment~~ example of the ~~invention~~disclosure, it may be provided that the at least one mover is arranged in the protected interior. It is advantageous here that many processes, in particular conveying and/or transport processes, can be carried out in the protected interior without manual intervention. A controlled exchange of air for example between the interior and the environment can thus be achieved. Such a controlled exchange is of great importance for aseptic applications with isolators or for toxic processes in containments. Furthermore, in some cases costly and time-consuming clean-room tests, in the form of e.g. microbiological culture plates, can be reduced. The design may for example allow the at least one mover to be operated in an interior into which no substances can enter uncontrolledly from the outside and/or from which no substances may escape uncontrolledly to the outside.

It may furthermore be provided that the at least one mover is arranged outside a protected interior. For a functional arrangement, accordingly a corresponding stator arrangement may be encased within the protected interior. Thus, advantageously, processes can be carried out outside the protected interior. This may prevent particles and/or contaminants caused and/or released by or at the stator arrangement escaping uncontrolledly from the interior.

In a further advantageous ~~embodiment~~ example of the ~~invention~~disclosure, it may be provided that the boundary wall of the protected interior has a coupling region of the stator arrangement and the at least one mover, in particular wherein the surface area inside the coupling region may be smaller than the surface area of the boundary wall. Here it is advantageous that further devices may be arranged outside the coupling region and/or in the protected interior, for example magnetically non-neutral devices and/or structures which may influence or interfere with the magnetic field or free movement region of the movers.

For example, gripper devices, weighing devices, closing systems, filling devices or conventional transport systems for manipulating containers may be arranged outside the coupling region.

In a further advantageous ~~embodiment~~ example of the ~~invention~~disclosure, it may be provided that the boundary wall and/or a, in particular the above-mentioned, coupling region is made of a magnetically neutral separating layer. Magnetically neutral in the sense of the ~~invention~~ disclosure means that the materials used can reduce or avoid an interference or deterioration in a magnetic coupling between the mover and stator arrangement.

For example, the separating layer may be made of or comprise a special steel and/or glass. Alternatively or additionally, the separating layer may also be made of a gas-tight plastic and/or composite material. Thus particularly suitable materials for protected interiors may be used.

Preferably, the separating layer is less than 2 mm thick. Thus the mover may be moved very close to the stator arrangement for a strong magnetic coupling.

In one ~~embodiment~~ example of the ~~invention~~disclosure, it may be provided that the boundary wall and/or a, e.g. the above-mentioned, coupling region is stabilised by carrier components. The use of carrier components is advantageous for the statics of the device.

Here it is favourable if the carrier components are made of magnetically neutral materials. Thus a fault with the coupling and/or deformation of the magnetic fields can be reduced or even avoided. This is particularly advantageous in connection with a magnetically neutral separating layer.

In a further advantageous ~~embodiment~~ example of the ~~invention~~disclosure, it may be provided that the stator arrangement is constructed in at least one rack. Here it is advantageous if the stator arrangement can be stabilised in the at least one rack.

It is favourable here if the at least one rack is mounted directly on the boundary wall and/or on a, e.g. the above-mentioned, coupling region. Thus the stator arrangement can be provided very close to the mover for a magnetic coupling.

Alternatively, the rack may also be positioned freely on the boundary wall and/or the coupling region in order to allow a more flexible movement of the rack.

Preferably, the at least one rack is movable from and to a usage site, and/or at the usage site can be adjusted between a working position close to the boundary wall and a position remote from the boundary wall. Since stator arrangements must be accessible, for example for maintenance and/or repair work, an embodiment of the stator arrangement in movable racks is advantageous. The rack may also advantageously travel to a position remote from the boundary wall, whereby stator arrangements can be extracted without themselves being damaged or causing damage to the boundary wall.

In a further advantageous ~~embodiment~~ example of the ~~invention~~disclosure, it may be provided that the boundary wall and/or the separating layer is removable from the device. It is advantageous here that the boundary wall and/or the separating layer can be extracted from the interior, whereby stator arrangements can be made accessible for economic maintenance.

In a further advantageous ~~embodiment~~ example of the ~~invention~~disclosure, it may be provided that the protected interior has at least two chambers, in particular wherein the at least two chambers are separated by an intermediate wall which preferably has at least one small access opening. It is advantageous here that different process steps of a method can be separated from one another in order to eliminate further sources of contamination and/or particles. The at least one small access opening according to the ~~invention~~ disclosure allows the transport of e.g. open vessels from one chamber to a further chamber in order to be filled and/or closed there.

Preferably, the intermediate wall is configured as a boundary wall at which the further processes can be carried out separately from one another.

Alternatively or additionally, in one of the chambers a positive pressure may be generated so that no contamination or particles from the other chamber can enter this chamber through at least one small access opening.

In a further advantageous ~~embodiment~~ example of the ~~invention~~disclosure, it may be provided that at least one process station is mounted fixedly or arranged on a mover in the protected interior. Thus objects can be processed flexibly in the protected interior throughout the entire manipulation process.

For example, a filling device may be fixedly mounted or positioned on a mover. A filling device allows regulation of the fill level of an object.

Preferably, the at least one processing station is situated on the boundary wall and/or in a, e.g. the above-mentioned, coupling region. In this way, highly advantageously, a multistage production process can be implemented in modular and dynamic fashion, since the movers can travel substantially freely on the drive surface and travel routes can easily be modified, in particular when the interior is closed and/or without moving parts. The modularity and dynamics according to the ~~invention~~ disclosure allow a method and/or process to be adapted and modified rapidly without endangering the protected clean room.

It is furthermore possible that the process station is arranged in one chamber and fixed in a second chamber. It is advantageous here that the process station can be positioned fixedly in one chamber, secure against contamination, and introduced into a second chamber for processing. For example, a process station may be introduced through an opening, for example through a lock, from one chamber to a second chamber.

In a further advantageous ~~embodiment~~ example of the ~~invention~~disclosure, it may be provided that the stator arrangement is fixed on the boundary walls and/or a, in particular the

above-mentioned, coupling region, and/or two adjacent walls of the protected interior, such that the at least one mover can

transport the at least one object inside the at least two chambers and/or through the at least one small access opening of the intermediate wall between the at least two chambers. It is advantageous here that working steps in which particles or contaminants may be released can be separated from following working steps. Thus a contamination transfer can be reduced or even prevented.

In a further advantageous ~~embodiment~~ example of the ~~invention~~disclosure, it may be provided that the stator arrangement is arranged preferably vertically inside the at least one intermediate wall between the at least two chambers. It is advantageous here that the at least one intermediate wall provides a drive surface for movers for lifting movements.

Alternatively or additionally, the at least one intermediate wall may also be produced as a coupling region which may comprise at least one magnetically neutral region for fixing of gripper devices, weighing devices, closing systems, filling devices or other processing stations for manipulating containers.

In a further advantageous ~~embodiment~~ example of the ~~invention~~disclosure, it may be provided that a stator arrangement is constructed inside the at least one intermediate wall in at least one rack. In this way, the stator arrangement can very easily be moved out of the intermediate wall for maintenance and/or repair work.

In an alternative or additional ~~embodiment~~ example of the ~~invention~~disclosure, it may be provided that the or a boundary wall and/or the or a separating layer can be removed from the intermediate wall. In this way, the or a stator arrangement is accessible from outside the interior for maintenance work, which is advantageous in particular if the or a stator arrangement is fixed stationarily, for example in stationary racks, in the intermediate wall.

In a further advantageous ~~embodiment~~ example of the ~~invention~~disclosure, it may be provided that the protected interior has at least one through-flow zone. Advantageously, the particle concentration

in the air can be reduced in a through-flow zone, which is advantageous for the purity of the product to be processed, in particular the products to be filled.

In particular, the drive surface may be configured such that the at least one mover can travel into the zone and/or within the zone. Accordingly, a through-flow zone may be implemented which has a smaller surface area than the surface area of the protected interior, and which movers can reach and travel over. It is advantageous with such a through-flow zone that less energy is required for the air flow, whereby costs can be saved. Advantageously, alternatively or additionally, a further means is provided, by which penetration of contaminants into a working region can be prevented.

In a further advantageous ~~embodiment~~ example of the ~~invention~~disclosure, it may be provided that the stator arrangement is enveloped by a sealed tunnel, wherein the drive surface is formed by an envelope of the tunnel. Thus advantageously, the drive surface may be formed on a tunnel inside the protected interior, wherein the drive surface and the mover can be installed compactly in the device.

Alternatively, it may be provided that the drive surface inside the protected area is formed independently of the envelope. In this way, in particular, a movement of the or a mover is possible separately from the envelope or tunnel, so that the or a mover moves and can be used flexibly inside the protected interior.

In a further advantageous ~~embodiment~~ example of the ~~invention~~disclosure, it may be provided that the tunnel is accessible on one side or two sides from outside the protected interior. This may be achieved for example with the access points described herein. Thus advantageously, stators of the stator arrangement can be accessed from outside the protected interior, in particular for maintenance and/or repair.

Alternatively or additionally, it may be provided that the tunnel is surrounded by the protected interior along a periphery running fully around its longitudinal extent. Thus the tunnel

may be completely integrated in the protected interior, whereby an integrity of the protected interior may be particularly high. Furthermore, advantageously space may be saved outside the protected interior.

In a further advantageous ~~embodiment~~ example of the ~~invention~~disclosure, it may be provided that the protected interior has a profile body, wherein the profile body comprises the stator arrangement and the separating layer. In this way, a drive surface for movers may be formed with a level difference relative to a floor of the protected interior, which can reduce contamination arising from the floor. The profile body may be inserted or erected in the protected interior, wherein the profile body in particular has at least one foot which forms a connection to the exterior of the protected interior, so that advantageously for example electrics can be routed to the profile body, in particular the stator arrangement. The at least one foot may also advantageously serve to dissipate waste heat from the stator arrangement, so that overheating of the device can be avoided.

In particular, it may be provided that the separating layer is attached interchangeably to the profile body. Thus the profile body may be closed so that no substance exchange occurs between the stator arrangement and the protected interior. The separating layer is interchangeable, whereby advantageously faulty stator arrangements and/or those requiring maintenance can easily be exchanged.

In particular, it may be provided that the separating layer is attached by adhesive to the profile body. Thus the profile body can be closed particularly easily. The profile body may also have adhesive surfaces for the separating layer so that the separating layer is not glued to the stator arrangement. In particular, in this ~~embodiment~~example, thus the separating layer lies on the stator arrangement such that no air gap occurs between the separating layer and the stator arrangement. Thus the magnetic coupling of the mover and stator arrangement may be formed particularly efficiently and fault-free.

Preferably, the separating layer is formed as a film. A separating layer formed as a film is particularly easy to handle, in particular if it is glued to the profile body as described above.

The separating layer formed by the film may, in a preferred and advantageous ~~embodiment~~example, be a glass-fibre composite. Further magnetically neutral materials may be used alternatively and as desired by the user for forming the separating layer.

In a further advantageous ~~embodiment~~ example of the ~~invention~~disclosure, it may be provided that the tunnel and/or the profile body form/forms access points outside the protected interior. Here, the access points are advantageously formed by the end faces of the tunnel and/or profile body. In particular, this ~~embodiment~~ example may simplify a removal of the stator arrangement e.g. for maintenance, without having to access the protected interior or contaminate this by manipulation. Thus operation in the device may be started or resumed particularly quickly.

In a second aspect, the present disclosure provides a method for filling at least one object with a device according to any of the preceding claims, characterized in that the at least one object is moved by a mover on a drive surface of the protected interior up to a process station, for example a filling device, and is filled by the filling device, wherein the filling device is positioned in the protected interior, in particular on the drive surface, or on a further mover.

Alternatively or additionally, for achieving the above-mentioned object, the features of the independent claim directed at a method are provided according to the ~~invention~~disclosure. In particular, in this way, in a method of the type described initially, it is proposed according to the ~~invention~~ disclosure that the at least one object is moved by a mover on a drive surface of the protected interior up to a process station, for example a filling device, and is filled by the filling device, wherein the filling device is positioned in the protected interior, in particular on the drive surface, or on a further mover. Preferably, it is provided that the mover with the at least one object carries out a lift movement to the filling device which is situated above the horizontal floor level of the device. Thus the vertically arranged filling device does not affect the transport

path of the device, whereby further movers can be conducted in flexible fashion to further process stations.

Alternatively, also a movement of the filling device to the mover with the at least one object is conceivable.

In a third aspect, the present disclosure provides use of a boundary wall of a protected interior as a drive surface of at least one mover which is coupled to a stator arrangement.

Alternatively or additionally, for achieving the above-mentioned object, the features of the independent claim directed at a usage are provided according to the ~~invention~~disclosure. In particular,

in this way, on use in the fashion described initially, it is proposed according to the ~~invention~~ disclosure that a boundary wall of a protected interior is used as a drive surface of at least one mover which is coupled to a stator arrangement. It is preferably provided that the stator arrangement is positioned outside the protected interior. Thus a physical separation of mover and stator arrangement is possible, which are not usually separated in a room. It is advantageous here that maintenance and/or adaptation of the stator arrangement of a protected interior, for example an isolator or containment, can be carried out in flexible fashion.

The ~~invention~~ disclosure is now described in more detail with reference to exemplary embodiments but is not restricted to the exemplary embodiments shown. Further exemplary embodiments arise from the combination of features of individual or multiple claims with one another and/or with individual or multiple features of the exemplary embodiments.

The drawings show, partially in cross-section:

Fig. 1 a side view of a device with stator arrangements and movers in different orientations,

Fig. 2 a side view of a device with a coupling region,

Fig. 3 a side view of a device with racks,

Fig. 4 a side view of a device with vertically arranged process stations,

Fig. 5 a side view of a device with two chambers,

Fig. 6 a side view of a device with two chambers and a stator arrangement in an intermediate wall,